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SUBTASK MEMORANDUM

Task: 3.3 How Well Do Measurements Characterize Critical Meteorological Features

Subtask 1 - Transport and Dispersion Under Light and Calm Winds

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Date: June 17, 2004

In this task, the ability of the CRPAQS network to adequately define important transport processes under light wind conditions are examined. The ability of the methods employed to measure light winds accurately --both at the surface and aloft-- was addressed in the various Tasks of work element 1.3. Task 2 of work element 1.3 demonstrated very good comparability of conventional wind measurements with the more sensitive sonic measurements, even under light winds. Task 3 showed that closely located monitoring sites had well correlated winds. Task 4; however, suggested differences between Sodar and conventional wind measurements at low wind speeds, likely due to limitations with the Sodar. These two work elements are inherently related. It should also be noted that all the wind profiler sites were audited, and the measurements compared with measurements made by a different method (i.e., rawinsondes) over the diurnal cycle, which usually included light winds and vertical shears.

During meteorological scenarios that produce light to calm winds within the surface boundary layer, there are often strong vertical wind gradients. Therefore, it is critical to accurately define the vertical wind profile at representative areas in the study domain in order to understand the three-dimensional transport processes. Moreover, when boundary layer winds are challenging the lower threshold of the monitoring equipment, are the measured winds reasonable? Needless to say, the final data validation is how consistent three-dimensional wind flow analyses are with the areal distribution of pollutants. The following discussion is more qualitative in nature.

January 8, 2000 was selected for study for a variety of reasons. Although it would have been more desirable to examine a period within one of the CRPAQS winter intensives, the Lemoore wind profiler site was not operational then. Lemoore, Angiola, and Visalia wind profilers were identified as providing the best set of measurements that met the requirements of this task. Lemoore and Visalia sites were aligned roughly due west-east approximately 40 km distant. The Visalia site was located on the eastern side of the SJV and potentially more influenced by the Sierra Nevada range. The Angiola site was ideally situated in the hydrologic center of the SJV adjacent to the Tulare Lake Basin, roughly 40-50 km from either of the other two sites. During the CRPAQS planning phase, measuring locations were selected to effectively capture important spatial differences while not being redundant. Therefore, measurements at these 3 sites by design will not be identical, and each can potentially add to our knowledge of the important processes. Particulate loading on January 7, the one-in-six sampling day, was the annual third highest in the SJV basin. Winds data on that day was incomplete; thus the following day was used instead. The meteorology remained similar and, as can be seen from

Table 1, particulate loading was as at least as high on the 8th. In the table, PM_{10} levels from both days at the three CRPAQS anchor sites, which made daily measurements, are given. Levels at the Fresno Supersite were substantially higher on the 8th whereas Bakersfield levels were somewhat less. Mass data was missing from Angiola on January 7.

Table 1. PM_{10} Levels(ug/m3) for CRPAQS Anchor Sites

Site	07-Jan	08-Jan
ANGI	missing	86.72
BAC	93.00	77.91
FSF	109.01	135.47

Synoptic meteorological conditions on January 8, 2000 were as follows. An Eastern Pacific high cell anchored a strong ridge over the western US with a deep trough over the midwest. On the 8th, light boundary layer winds dominated Central California. In the afternoon, a short-wave trough riding over the East Pacific ridge resulted in an increase in the low level winds but overall boundary-layer transport winds generally remained light. Diurnal time-height cross-sections of the wind profiler measurements are given in **Figures 1, 2 and 3**.

January 8, 2001 measurements were selected for the particularly light boundary layer winds that persisted coupled with strong vertical wind shears. The maximum mixing depth was estimated from the radar profiler and RASS to be approximately 500-600 meters-agl. Very light winds from varying directions were measured in the surface boundary layer whereas more uniform, moderately strong winds from the NNW to N were measured above this level. West to east horizontal wind shears were present as well. Winds above the boundary layer increased throughout the day while the winds below 500 m-agl remained light. This is graphically depicted by the time-height cross-sections as well as the trajectories shown in **Figure 4**.

Figure 4 shows back trajectories at 220m and 1000m at the three sites; Angiola and Visalia generated from radar wind profiler measurements on Jan 8, 2001. The black solid line depicts the 220m trajectory. The red broken line depicts the trajectory at 1000m. The trajectories in the figure show that under light boundary layer winds, profiler measurements appear to behave very reasonably in that the air parcel trajectories of all three sites "meander" over a 24 hour period within or very close to a radius of 43 km from the sites (indicated by blue circles on figure). This radius defines the maximum distance a parcel transporting at 0.5 m/s will travel (in any direction) over 24 hours. These wind speeds challenge the threshold of most monitoring methods. Note that the Visalia (VIS) parcel originated 24 hours before at approximately 5 km distant, at Angiola approximately 30 km, and at Lemoore approximately 50 km. In any event, the only certain conclusion is that winds were meandering during this period and transport was minimal.

Vertical wind shear was evident at all three sites as the 1000 meter trajectories depict. One-thousand meters was well above the surface boundary layer throughout the diurnal cycle and more in line with the larger-scale regional wind field. Horizontal shear is very much in evidence at this level. Twenty-four-hour trajectory horizontal distances (assuming a constant horizontal wind field) were 575 km, 463 km, and 177 km for Lemoore, Angiola, and Visalia, respectively.

The trajectories were all indicative of northerly flow, which is consistent with the 850 mb (~1,500 meter) synoptic weather maps.

Assuming the profiler performance at these three sites is representative of all the profilers in the CRPAQS network, the network appears capable of adequately measuring light winds and vertical wind shears. In contrast to the 220m-agl winds, winds above the boundary layer (maximum mixing was ~ 600m-agl) were well-organized and moderate in strength.

One of the principal uses of profiler data will be to determine air fluxes, ventilation rates and transport. The along-valley and cross-valley diurnal volume fluxes were computed for the three sites for January 8, 2001. Fluxes were normalized to a km-wide, 500m high plane. This depth is consistent with the maximum mixing depth on that day. **Figure 5** shows the diurnal time-series of the fluxes. Component winds were lined up with the longitudinal axis of the SJV. Positive along-the-valley flux (upper panel) is defined as NW to SE. A positive cross valley flux is defined as SW to NE.

From these of plots, it is apparent that the fluxes, computed from the radar wind profiler measurements at the sites, show similar trends, and for the most part the major events are well correlated. Angiola generally exhibited the greater up-valley and cross-valley flux--most noticeably in the morning. During the afternoon, beginning at 15 PST, the up-valley fluxes became quite different. Whereas the boundary layer flux at Lemoore was up-valley, Visalia and Angiola measured down-valley fluxes. This resulted in significant differences in total low-level flux over the diurnal cycle. **Table 2** shows the net 24-hr flux normalized over a 0.5 km vertical plane. Visalia experienced a net down-valley (SE-NW) flux as did Angiola but to a lesser extent. Lemoore exhibited a net up valley flux. Visalia and Angiola show an equal net cross-valley flux from NE-SW. The net cross-valley flux at Lemoore was also NE-SW.

Table 2. Net 24-hr Volume Flux (km^3) on January 8, 2000

Site	Along-the-Valley	Cross-Valley
Visalia	-28	-9
Angiola	-4	-10
Lemoore	+8	-21

A final evaluation approach was to examine the time-series of the wind differences to look for variations over the diurnal cycle. **Figure 6** shows the along-valley and cross-valley wind component differences for two of the sites in a time-height cross-section format. The along-valley differences are shown in the top panel and the cross-valley differences shown in the bottom panel.

The salient features of this data are: throughout the morning and early afternoon differences were less than 2 m/s in the lower 2000m; beginning in late afternoon significant along-valley (NW to SE) differences developed although they were still less than 2 m/s in the lower 500m. However, differences as great as 7 m/s were observed in a layer approximately 800-1000m. These differences were due to both to different scalar wind speed as well as directional differences (Angiola winds in this layer exhibited a more northerly direction). This feature, also shown by the trajectories, could be caused by the changing terrain features on the east side of the SJV.

In summary, radar wind profilers appear to characterize light winds reasonably well, and define vertical wind shears. Substantial differences in the magnitude and direction of the winds were observed above the boundary layer but below the complex terrain that defines the SJV. It is important to note that the field study design selected upper air sites as to not be redundant. The differences observed in the low-level trajectories are very reasonable considering the light and variable nature of the wind field and local topographic differences. It is interesting to note that over the diurnal cycle, fluxes for two or more of the sites were in excellent agreement, and that all three sites shared similarities (i.e. none of the sites appeared as outliers throughout the entire diurnal cycle).

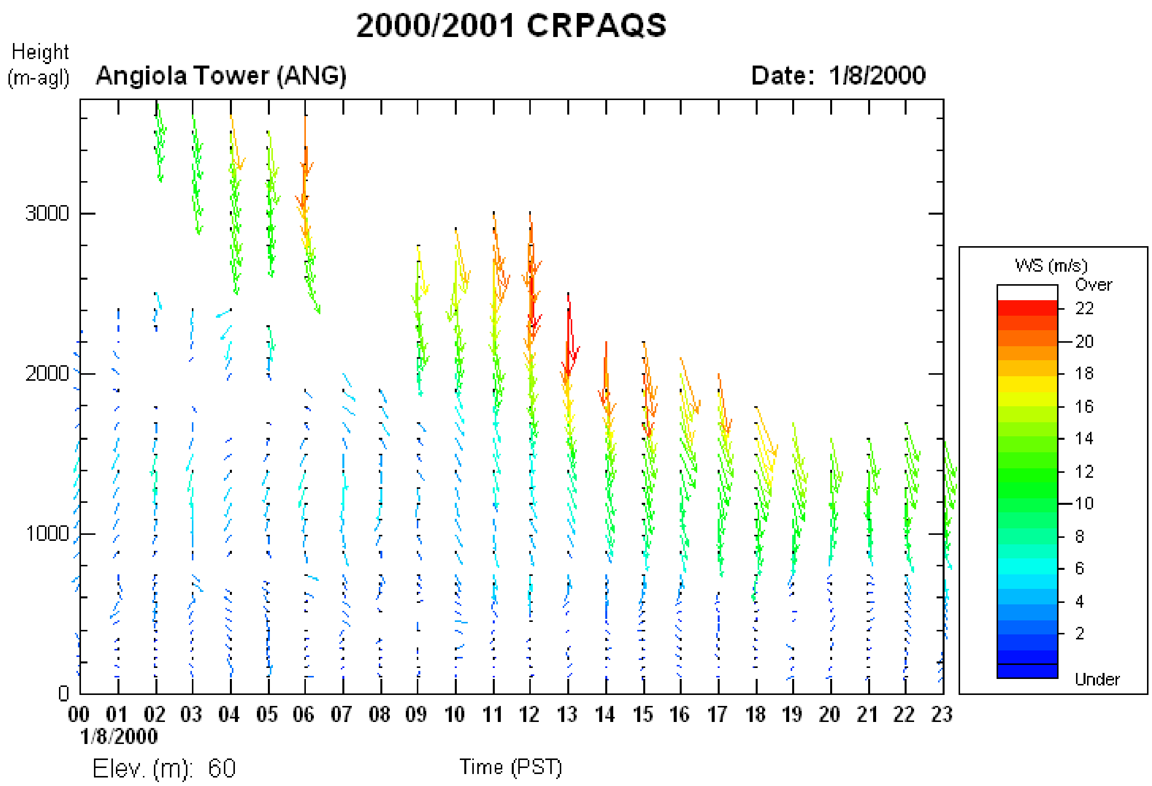

Figure 1. Time-height Cross-section of the winds at Angiola on January 8, 2000

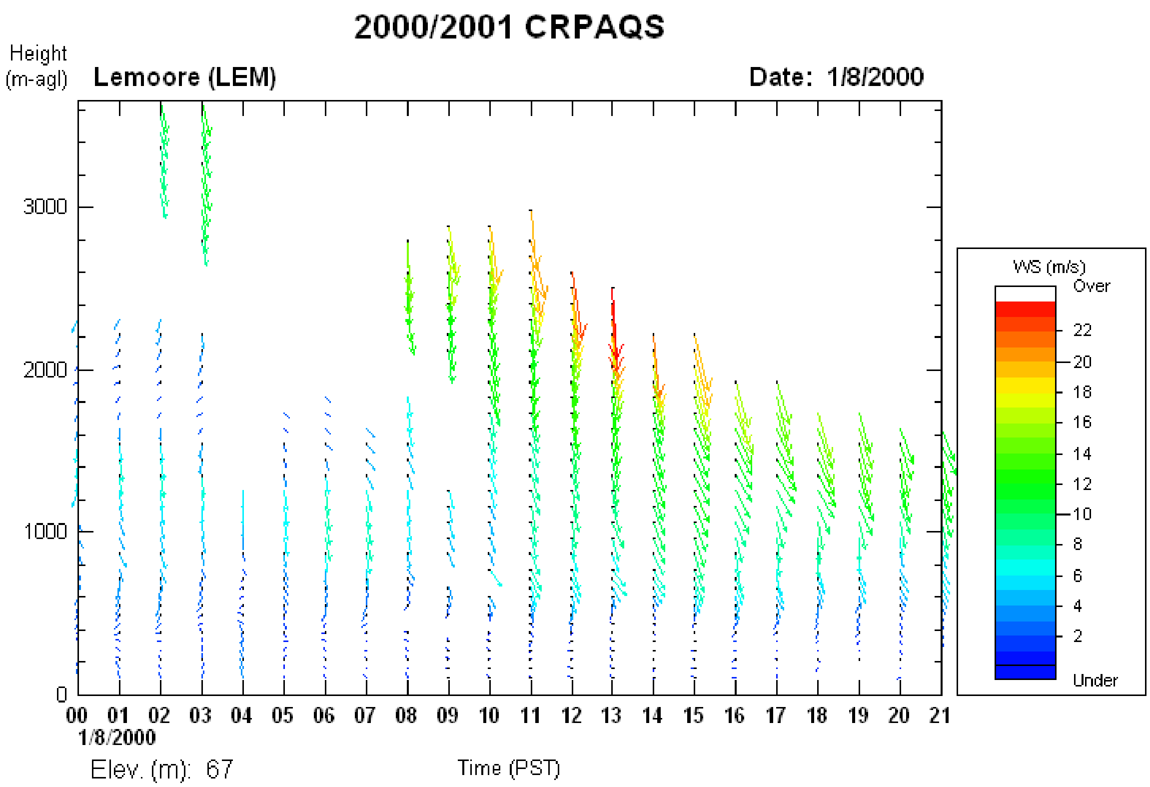

Figure 2. Time-height Cross-section of the winds at Lemoore on January 8, 2000

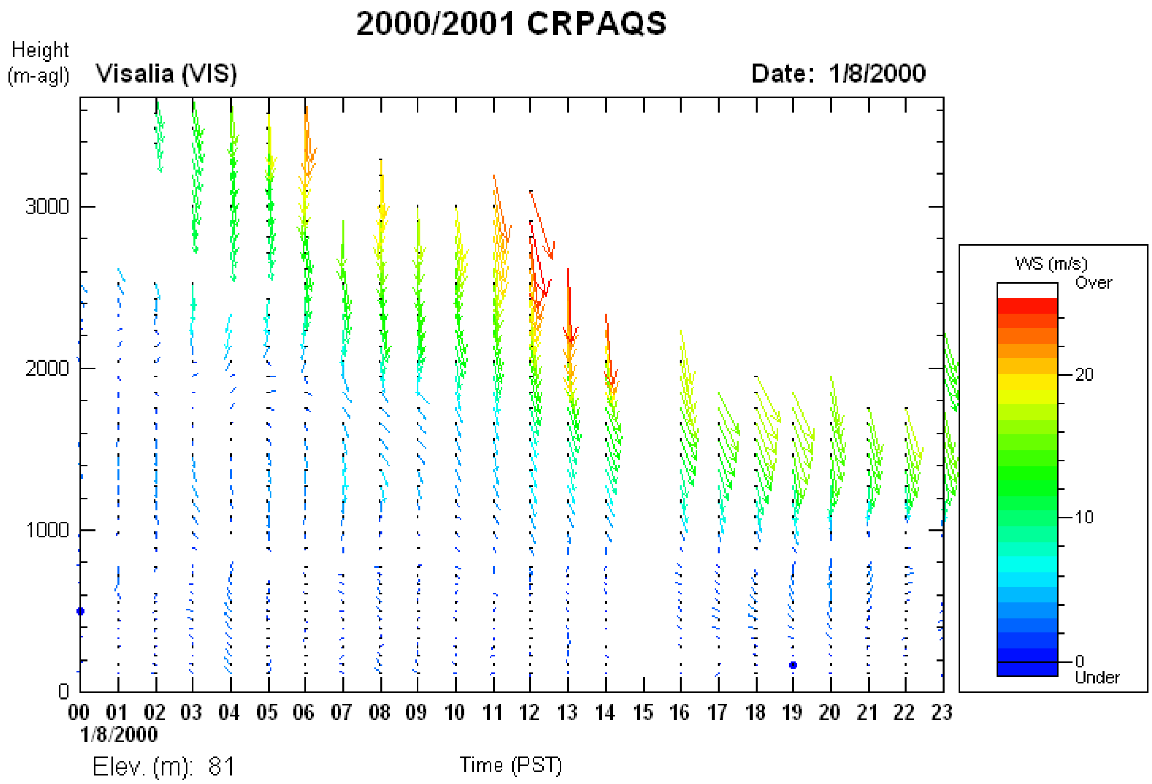

Figure 3. Time-height Cross-section of the winds at Visalia on January 8, 2000

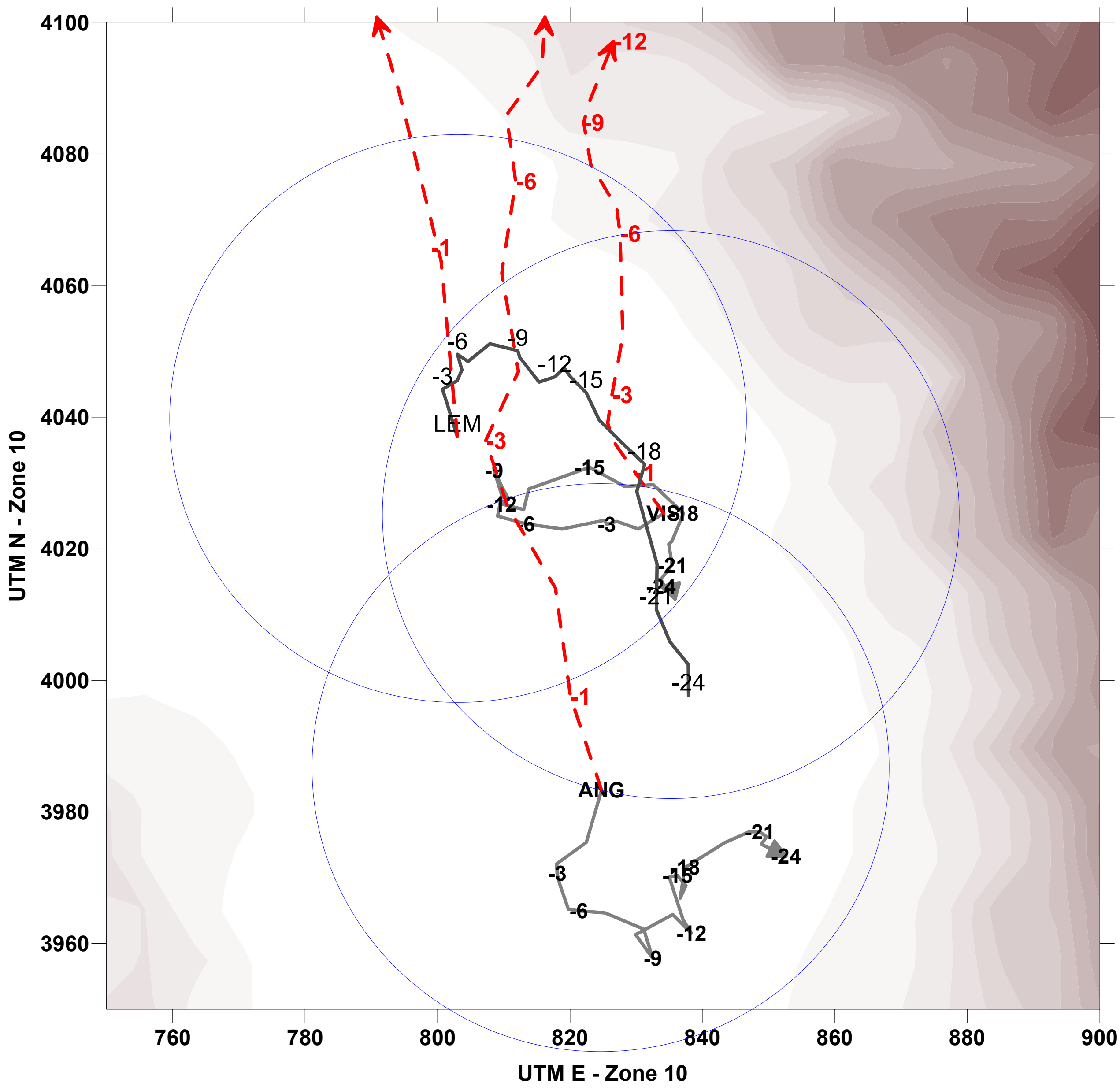

Figure 4. Air Parcel Backtrajectory at 220m-agl (black/solid lines) and 1000m-agl (red/broken lines) From Angiola and Visalia on January 8, 2001. (Labels are hours prior to end point. Circles depict an operational 24-hr trajectory uncertainty based on a maximum accuracy of 0.5 m/s)

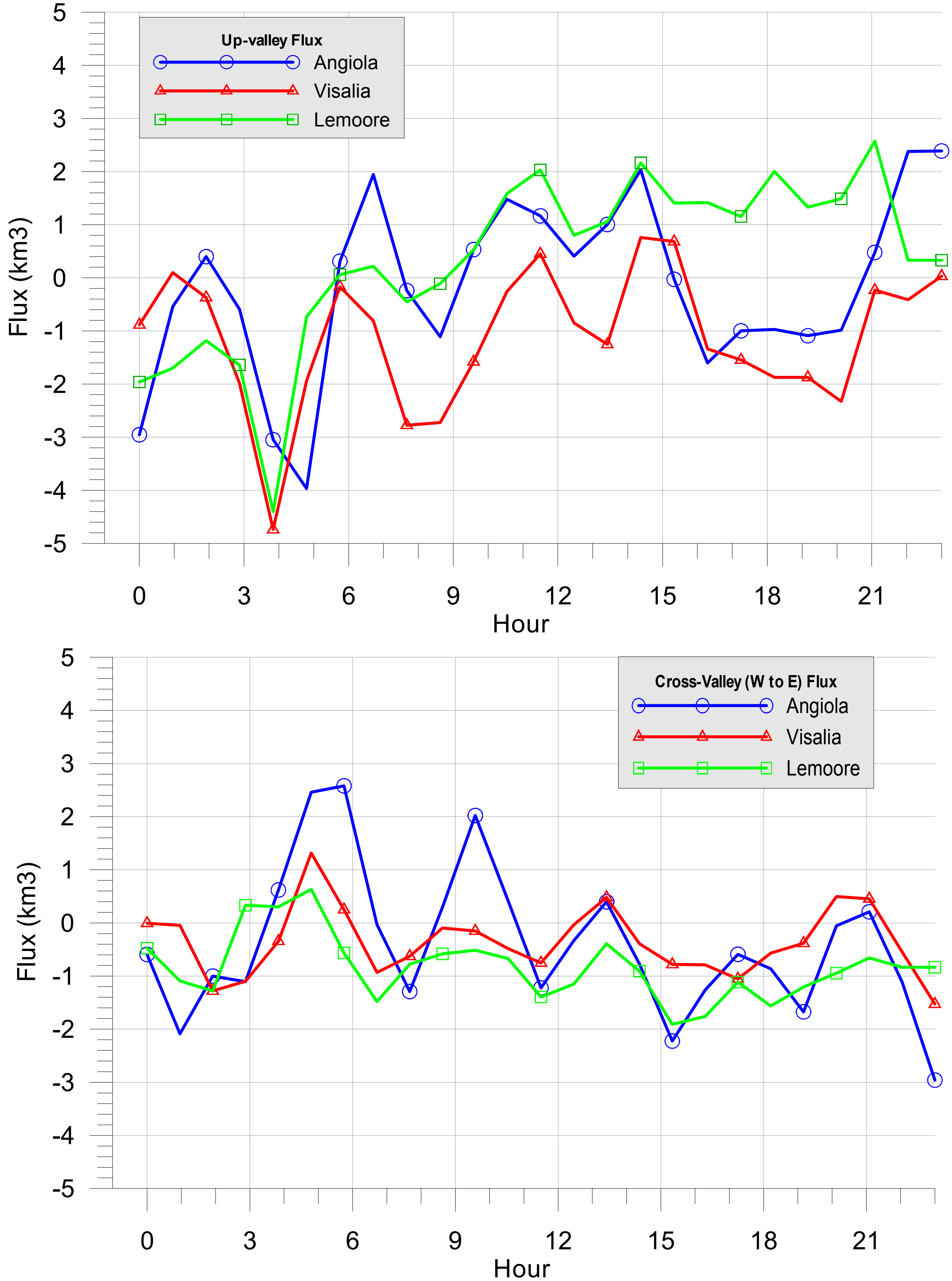

Figure 5. Diurnal Flux (Normalized) within Boundary Layer (<500m) on January 8, 2000
Along-Valley (top panel) and Cross-Valley (bottom panel)

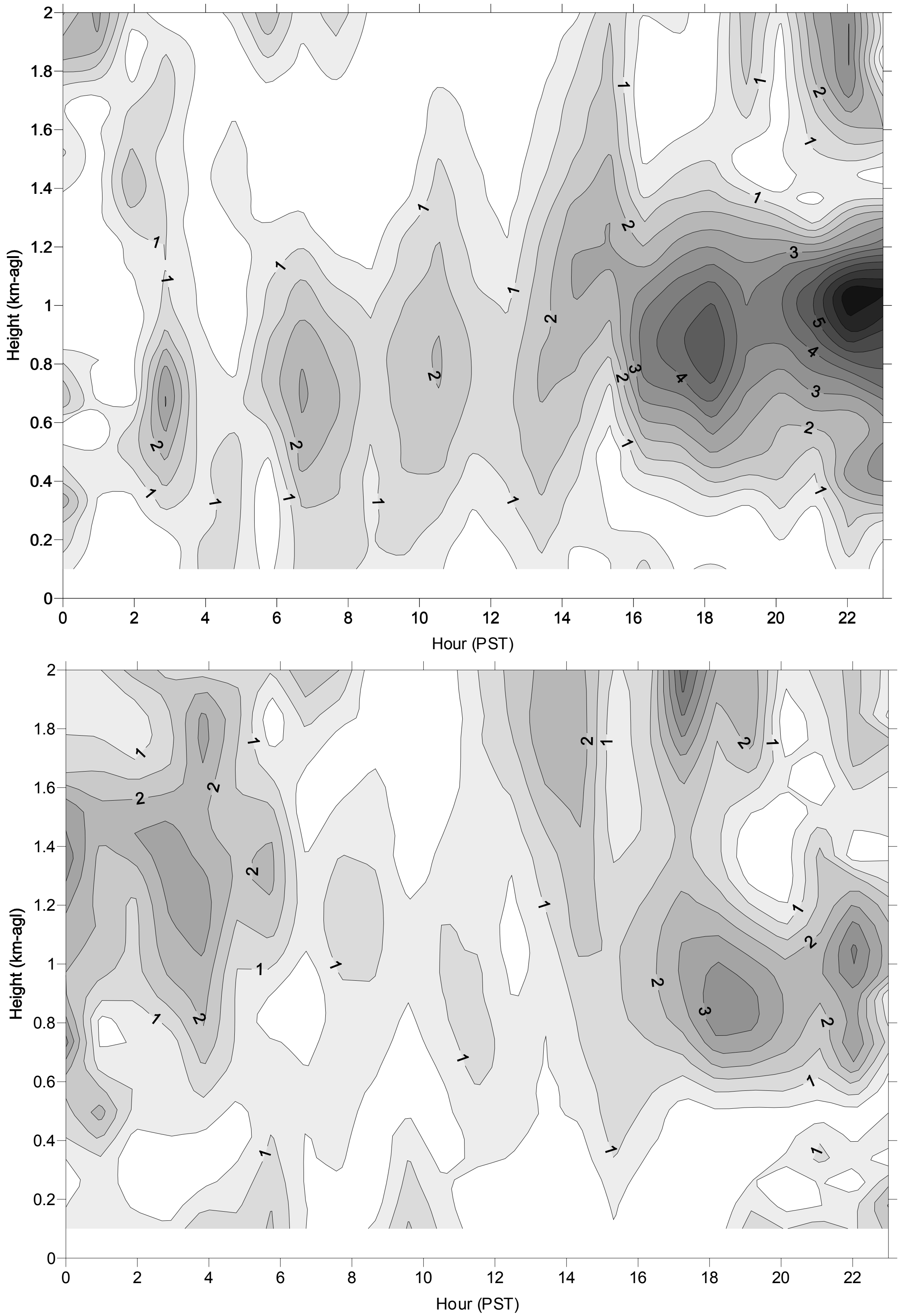

Figure 6. Wind Component Difference (m/s) Between Angiola and Visalia on January 8, 2000. Cross-valley component shown on top panel and along-valley component on bottom.